Rescue of a Bryde's Whale *Balaenoptera edeni* entrapped in the Manning River, New South Wales: unmitigated success or unwarranted intervention?

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ABSTRACT

In August 1994 a Bryde's Whale *Balaenoptera edeni* entered and became entrapped in the Manning River, New South Wales. The individual was an immature male of the rare pygmy form of Bryde's Whale; it was 10.3 m long and weighed approximately 7.7 tonnes. The whale remained in the river for 100 days, during which time observations were made of its movements, diving habits, feeding behaviour and body condition. Apart from the risk of stranding, the entrapped whale also faced the potential threats of starvation, entanglement in fishing nets, collision with boat traffic, and exposure to low salinity and high acidity. In view of these threats, a rescue bid was launched to return the whale to the ocean. Five rescue attempts were made, the last culminated in the whale being successfully towed to sea and released several kilometres offshore. Despite its emaciated condition the whale was rescued from the river before the onset of ill health or irreparable physiological damage. The whale swam away strongly on release, and its chances of survival appeared to be good. The success of the operation together with the physical state of the animal on release justify the decision taken to mount such an ambitious rescue bid, even though such action was itself life-threatening.

INTRODUCTION

Bryde's Whales *Balaenoptera edeni* occur in tropical, subtropical and warm temperate waters around the world (Cummings 1985), often near shore in areas of high productivity (Leatherwood and Reeves 1983). In Australian waters they are most often observed north of 40°S (Watson 1981; Leatherwood and Reeves 1983). Reported strandings, as shown in Figure 1, have been confined to the southern and southeastern coast of the Australian mainland (Dixon 1970; Llewellyn *et al.* 1994; Marine Mammal Strandings Database, Biodiversity Group, Environment Australia).

On 16 August 1994 a 10.3 m long Bryde's Whale entered the Manning River on the central coast of New South Wales. The whale remained entrapped in the river for 100 days, apparently unable to negotiate its way back out to sea through the shallow, narrow channel at the river mouth. In view of the potential threats to the whale whilst in the river (see below), a bid was made to rescue the whale and return it to the ocean.

Several rescue strategies were tried. The first was to drive the whale downstream, through the mouth of the river, across the bar and out to sea. When this failed, a second strategy aimed to capture the whale then tow it to sea on an inflatable pontoon. Three attempts to capture the whale were made; all failed. On 24 November 1994, before another capture attempt could be initiated, the whale grounded on a sand shoal close to the river mouth. While stranded, the whale was successfully manoeuvred on to a pontoon, towed out to sea and released several kilometres offshore. The whale had been entrapped in the Manning River for 100 days, during which time observations were made of its movements, diving habits, feeding behaviour and body condition.

Since the rescue, debate has ensued regarding the need for such intervention and the worth of such operations. This paper examines the incident in relation to similar historical events, discusses the potential threats to the whale in the river, and reports on the biological and behavioural information gathered. The findings, and the benefits of hindsight, are used to appraise the decision to mount a rescue bid.

THE MANNING RIVER

The Manning River is a short coastal river, rising in the foothills of Mount Barrington in the Great Dividing Range about 150 km from the coast and meandering for its final 50 km across a coastal plain until forming an estuary, out of which it enters the Pacific Ocean. It is a typical estuarine river, as described by Morrisey (1995), of which there are many on the New South Wales coast. Several factors influence the form of these estuaries. Rainfall in Australia is erratic, and river flows are highly variable and unpredictable. The ocean swell is consistently substantial and virtually parallel to the coast. As a result, estuaries of this kind tend to have convoluted and shallow passages, a bar across the mouth and a narrow channel, the location

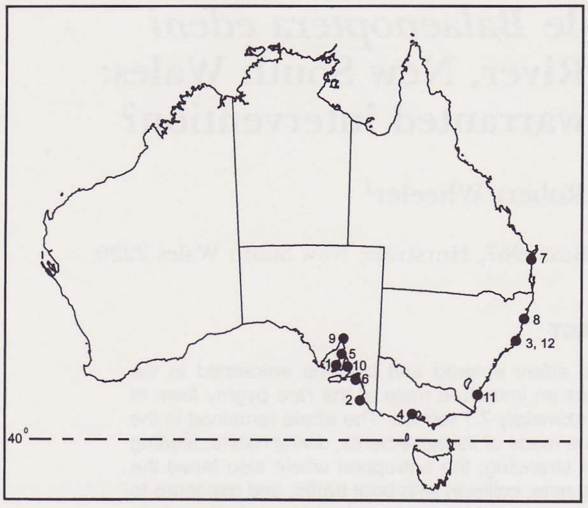

Fig. 1. Australia, showing locations of reported strandings of Bryde's Whales. Key: 1, Corny Point (1883); 2, Cape Banks (1945); 3, Manning River (July 1948); 4, Corio Bay (July 1968); 5, Port Wakefield (April 1972); 6, Younghusband Peninsula (January 1982); 7, Great Sandy Strait (October 1982); 8, Valla Beach (October 1983); 9, Red Cliff Point (September 1985); 10, North Brighton (July 1986); 11, Hayward's Beach (November 1989); 12, Manning River (August to November 1994).

of which is very changeable. The European settler has, on virtually every such river, endeavoured to deepen and stabilize the passage by various measures.

The Manning River estuary is shown in Figure 2 and has two entrances to the ocean. The main channel flows to Harrington Inlet (31°53′S; 152°41′E) and the smaller South Channel and Scotts Creek flow to Farquar Inlet (31°57′S; 152°36′E). Harrington Inlet, where extensive sand shoals extend almost 3 km upstream from the river mouth, is the major passage for boat traffic entering or leaving the river. The narrow channel, which has been redirected by a long training wall (Fig. 3), is convoluted and shallow and can be difficult to navigate.

The whale entered the Manning River during a period when protracted drought conditions prevailed over most of eastern Australia. The Manning River catchment was severely affected, and was drought declared from August to November 1994 (New South Wales Department of Agriculture, unpubl. data). The annual rainfall at Taree during 1994 was 555 mm, 46% of the long-term (109-year) average (Meteorological Records Database, Australian Bureau of Meteorology). The 110 mm of rain that fell during the four-month period encompassing the whale's entrapment (August to November) was 39% of the long-term mean for this period. River flows were substantially reduced because of the protracted drought. Total stream discharge from August to November 1994, as measured at Killawarra (32 km upstream from Taree), was less than 20 000 ML (New South Wales Department of Land and Water Conservation, unpubl. data). Discharge volumes for the corresponding periods in 1990–93 were substantially greater: up to 140 000 ML.

Low river flows in recent times resulted in the constriction and further redirection of the channel in Harrington Inlet. The channel was not expected to widen or deepen until the next major river flow.

ENTRY OF THE WHALE INTO THE RIVER

At approximately 1300 h on 16 August 1994, the whale grounded on a sandbar at the mouth of the Manning River (Fig. 3). The tide was 1.1 m, peaking at 1.65 m around 1600 h. The whale remained grounded on the sandbar until, on the rising tide, it refloated and was swept by waves off the sandbar into the river. It ran aground again on a sand shoal approximately 2 km upstream (Fig. 3) where it floundered for 20 min. before again being refloated by the incoming tide. Minimum water depth between the heads when the whale crossed was 4.6 m on the northern side and 2.2 m on the southern side (Hydrographic Office, Royal Australian Navy, unpubl. data).

Local fishers followed the whale upstream for several kilometres before it disappeared. It was next sighted the following morning in the South Passage at the mouth of Blackfords Bay approximately 23 km upstream (Fig. 2). The whale remained in this vicinity for several weeks, rarely venturing upstream of Dumaresq Island or downstream of Blackfords Bay.

Why the whale entered the river is unclear, although it appeared to be due to miscalculation rather than intention. A local fisher who witnessed the event believed that the whale got into difficulties while feeding at the river entrance where schools of young Tailor *Pomatomus saltatrix* were plentiful around the time of the incident. The whale ran aground while feeding in shallow water and, once grounded, could not turn around. It was subsequently swept over the shoals and into the river by breaking waves. A pod of Bottlenose Dolphins *Tursiops truncatus* was also present nearby and preceded the whale upriver. They too appeared to be hunting shoaling fish.

THE RESCUE OF THE WHALE FROM THE RIVER

The Drive

The first strategy to remove the whale from the river was to drive the animal downstream by producing a noise barrier created by banging metal pipes suspended in water from a flotilla

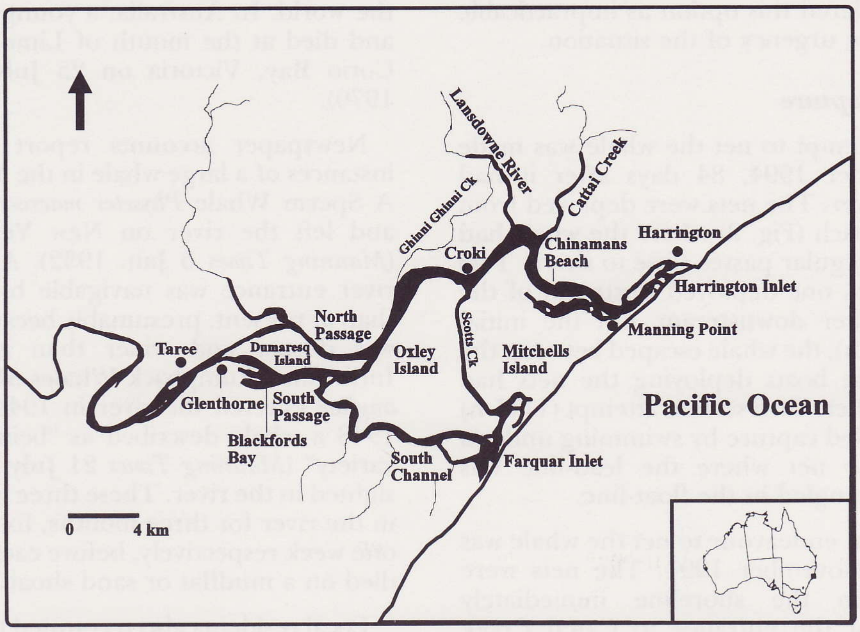

Fig. 2. The lower reaches of the Manning River showing locations mentioned in the text.

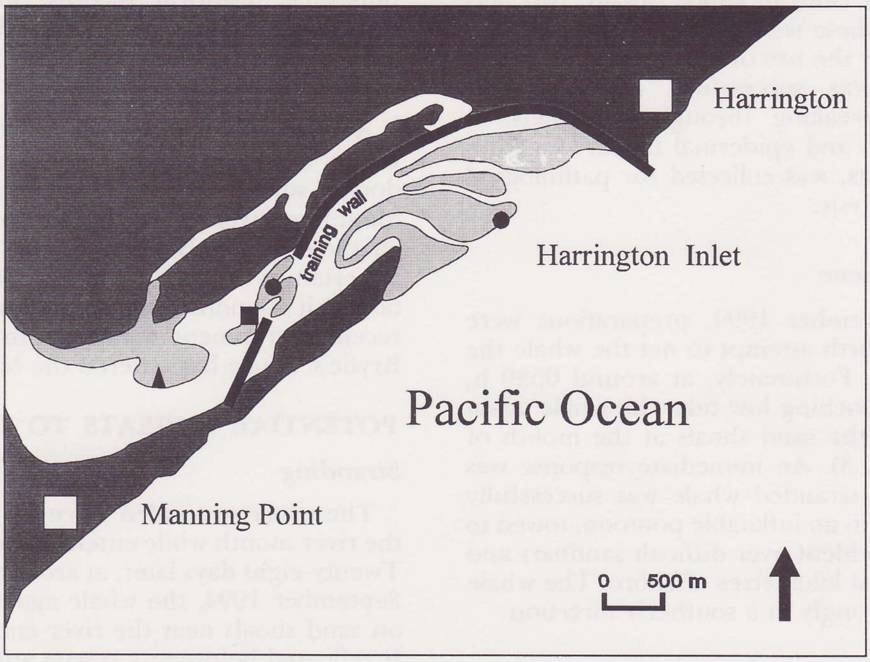

Fig. 3. Harrington Inlet at the mouth of the Manning River showing sites of groundings of the entrapped whale. Heavy stippling, land; light stippling, sand shoals; circles, sites of grounding on 16 August 1994; triangle, site of grounding on 13 September 1994; square, site of grounding on 24 November 1994.

of small boats. The drive took place on 10 October 1994, 55 days after the whale entered the river. The rescue attempt drove the whale approximately 19 km downstream to within 1 km of the network of sand shoals at the river mouth. In spite of a determined effort to drive it through the narrow channel to the ocean, the whale would go no further downstream. It was either unable to navigate the narrow channel between the many shoals in the river mouth, or unwilling to venture into an area where it had grounded previously.

Deepening of the channel by mechanical means would have involved the dredging of massive quantities of sand. An operation of such magnitude would be subject to several planning and environmental regulations and would, therefore, require considerable government and public scrutiny. The protracted nature of such

a process rendered this option as impracticable considering the urgency of the situation.

Attempts at Capture

The first attempt to net the whale was made on 8 November 1994, 84 days after it had entered the river. The nets were deployed from Chinamans Beach (Fig. 2) where the whale had been making regular passes close to shore. Two nets were used, one deployed upstream of the whale, the other downstream. On the initial attempt (0745 h), the whale escaped between the nets before the boats deploying the nets had passed each other. On a second attempt (1115 h) the whale evaded capture by swimming under a portion of the net where the lead-line was inadvertently tangled in the float-line.

A subsequent endeavour to net the whale was made on 12 November 1994. The nets were deployed from the shoreline immediately downstream of the entrance to Cattai Creek (Fig. 2). As in the previous attempt, the nets were readied where the whale had been making regular passes close to shore. Again, two nets were set, but these were deployed more quickly than before by the use of more powerful boats. The whale was successfully encircled, but escaped by breaking through both nets. A sample of skin and epidermal tissue, lodged in one of the nets, was collected for pathological and DNA analysis.

The Final Rescue

On 24 November 1994, preparations were afoot for a fourth attempt to net the whale the following day. Fortunately, at around 0530 h, and just approaching low tide, the whale again grounded on the sand shoals at the mouth of the river (Fig. 3). An immediate response was initiated. The stranded whale was successfully positioned on to an inflatable pontoon, towed to sea without incident over difficult sandbars and released several kilometres offshore. The whale swam away strongly in a southerly direction.

HISTORICAL PERSPECTIVE

Historically, the stranding of a whale was a welcome event and an occasion for local Aboriginal people to eat to repletion. Nowadays such events are viewed with solemnity and invoke great concern for the welfare of the distressed animal.

Strandings of Bryde's Whales are relatively uncommon, but the occurrence of this species up a river is not without precedent. The type specimen was found stranded about 32 km up a small river in Burma (Anderson 1878). Since then, there have been several incidences of Bryde's Whales in rivers and estuaries around the world. In Australia, a young male stranded and died at the mouth of Lime-burner Creek, Corio Bay, Victoria on 25 July 1968 (Dixon 1970).

Newspaper accounts report four previous instances of a large whale in the Manning River. A Sperm Whale *Physeter macrocephalus* entered and left the river on New Year's Day 1932 (*Manning Times* 6 Jan. 1932). At this time the river entrance was navigable by larger vessels than at present, presumably because the channel was deeper and wider than it is currently. Individual Humpback Whales *Megaptera novaeangliae* entered the river in 1944 and 1945. In 1948 a whale described as "being of the black variety" (*Manning Times* 21 July 1948) was also sighted in the river. These three whales survived in the river for three months, four months, and one week respectively, before each stranded and died on a mudflat or sand shoal.

Local residents also recounted two, or possibly three, whales entering the Manning River in 1942, but this incident could not be verified by published historical records. Reputedly, one whale became stranded and died, one was allegedly shot, and the third (if it existed) apparently found its way back to sea.

A photograph taken in the 1940s depicts a whale with three longitudinal ridges on the dorsal surface of its head stranded in the Manning River. Such ridges are a diagnostic characteristic of Bryde's Whale. Although it is uncertain as to exactly when the photograph was taken, it demonstrates unequivocally that the recent entrapment is not the first time that a Bryde's Whale has entered the Manning River.

POTENTIAL THREATS TO THE WHALE

Stranding

The whale grounded twice on sand shoals at the river mouth while entering the river (Fig. 3). Twenty-eight days later, at around 1000 h on 13 September 1994, the whale again ran aground on sand shoals near the river entrance (Fig. 3). It refloated before any rescue attempt could be initiated or blood samples taken. A subsequent grounding in the same vicinity (Fig. 3) on 24 November 1994 eventually led to the animal's rescue and return to the ocean.

Although on three occasions the grounded whale refloated on the rising tide, these groundings were potentially life-threatening. Three of the other four whales known to have entered the Manning River stranded and died, each taking several days to succumb.

A depth profile of the estuary, prepared by the New South Wales Department of Public Works, revealed a raised river floor across the narrow channel between the sand shoals. Visual

inspection confirmed the existence of a submerged ridge extending the full width of the channel, which at low tide was covered only by about 1 m of water. This ridge in the river floor together with the configuration of sand shoals either side of the narrow, shallow channel (Fig. 3) was thought to be preventing the whale from returning to sea.

Insufficient Food

Bryde's Whales are less migratory than other Baleen Whales (Best 1960; Carwardine 1995), and do not undertake annual migrations to the Antarctic. There is no evidence that Bryde's Whales fast like those species that feed predominantly in the polar regions. On the contrary, Bryde's Whales have been recorded feeding throughout the year (Watson 1981; Carwardine 1995), and at least twice or perhaps as many as five times daily (Best 1977). The diet consists primarily of small shoaling fish such as pilchard, mackerel, herring, anchovy and sardine (Chittleborough 1959; Nemoto 1959; Best 1967, 1977). Crustaceans constitute an important component of the diet in some areas, particularly in offshore waters where cold-water upwellings support plankton blooms (Best 1977; Watson 1981). Cephalopods have also been reported in the diet (Best 1977).

Sergeant (1969) postulated that adult Baleen Whales need to consume, on average, the equivalent of 3–4% of their body weight daily. Gaskin (1982) considered this estimate to be too high, claiming that the minimum quantity of food needed to sustain an adult rorqual whale is around 2.5–3.0% of body weight per day. From this more conservative estimate and the assessment of body size (see below), the food requirements of the Bryde's Whale entrapped in the Manning River was calculated to be approximately 200 kg per day.

Several areas frequented by the whale during its entrapment in the Manning River were trawled to assess local potential food stocks. The trawls were made with an otter prawn net comprising a 30 mm mesh with a 3 m mouth. A 20 min. trawl off Chinamans Beach (Fig. 2) and another of similar duration several kilometres upstream netted nothing. The mouth of Cattai Creek (Fig. 2) was trawled for 30 min., netting only three fish. A 15 min. trawl further upstream in Cattai Creek, an area where prawns were thought most likely to occur, produced nothing. Although the whale was observed attempting to feed, the apparent dearth of fish and crustacea in the river raised concerns that it may have been unable to catch sufficient food to sustain itself in the long term. The length of time a Bryde's Whale can abstain from food without causing irreparable physiological damage is unknown.

Boat Traffic

The Manning River is a popular holiday destination and a haven for recreational activities such as fishing, sailing and water skiing. The river is a busy waterway for all kinds of small boat craft including speedboats, cruisers, houseboats and fishing trawlers. The lower reaches are commercially fished and also support a substantial oyster farming industry. The potential for collision with boats or entanglement in fishing nets was a threat to the whale and a risk to public safety.

Shortly after entering the Manning River, the whale took up residence in South Passage of the river near Dumaresq Island. On advice from the National Parks and Wildlife Service, the South Passage was immediately closed to all recreational traffic. A few weeks later, as the whale became more wide-ranging, this restriction was revoked in favour of establishing an exclusion zone around the whale wherein vessels were required to maintain at least 100 m between themselves and the animal. Although the whale was legally protected from interference from river traffic, its safety in the river could not be assured.

Salinity

The farthest upstream stretch of the Manning River occupied by the whale during its period of entrapment was between the western end of Dumaresq Island and the road bridge across the river at Taree (Fig. 2). Water salinity in this area was 29% compared to 35% in oceanic waters outside the heads. Although the long-term effects of exposure to low salinity are unknown, the level of salinity in the river was not considered dangerous for the whale in the short term. Of greatest concern was the potential threat that local heavy rains could cause a substantial and rapid reduction in salinity. Salinity levels as low as 5% have been recorded in the river just off Manning Point (Fig. 2) during times of significant fresh water flow (McCotter 1993).

Low salinity may potentially disrupt the whale's normal osmotic process, causing body salts to leach out of tissues and water to seep in (Roletto 1986). The effect of this osmotic process is water-logging of the skin with potentially lethal consequences. The skin may change colour and eventually slough. Reduced salinity will also make the animal less buoyant, causing the animal to expend excessive energy when swimming and when surfacing.

Acidity

During the whale's entrapment, the pH of the river was between 7.6 and 7.8, commensurate with oceanic waters, and posing no immediate threat to the whale. The prevailing drought,

◁
The purpose-built pontoon being readied for the rescue operation.
Photo by Lawrence Orel, NPWS.

▷
The whale was held gently while the partially-inflated pontoon was carefully manoeuvred into position.
Photo by Lawrence Orel, NPWS.

◁
When correctly positioned the whale's tail fluke protruded beyond the rear of the pontoon. When subsequently adjusted and inflated, the pontoon encased the whale sufficiently to restrain it.
Photo by Lawrence Orel, NPWS.

▷
Blood and tissue samples were taken while the whale was held within the pontoon. Abrasion to the leading edge of the tail fluke, the result of swimming in shallow water, is clearly visible.
Photo by Lawrence Orel, NPWS.

however, had caused many of the tributaries of the Manning River to stop flowing, and several swamps were dry for the first time in living memory. Exposure and drying of underlying acid-sulphate pyrite soils can cause a substantial increase in soil acidity (Dent and Pons 1993). The acid arises from oxidized pyrite that was originally buried under wet sediment but which, due to altered drainage patterns and drought, may become exposed to the air. After heavy rain the first run-off from these soils will flush large quantities of highly acidic leachate from the soil into the river. The extent of the resultant rise in acidity is unpredictable. In the nearby Tweed River catchment, heavy rain after a two-year drought led to a discharge of acidic water into the Tweed River. More than 20 km of river system was affected by increased acidity which caused the death of substantial numbers of fish and crustacea (Tunks 1993).

Pesticide Residues

The prolonged use of chemical pesticides for agriculture and the presence of riverside industry have the potential to lead to the accumulation of pesticide residues in the river. River water was tested for the presence of a broad range of organochlorine pesticides, including DDT, DDE, DDD, BHC, chlordane, heptachlor, aldrin, endosulphan, dieldrin and endrin. None was present in detectable quantities.

BIOLOGY AND BEHAVIOUR OF THE ENTRAPPED WHALE

Taxonomy

Morphometric variation between different populations of Bryde's Whale suggest there may be several different forms or races (Chittleborough 1959; Omura 1959; Masaki 1975; Kawamura and Satake 1976; Best 1977; Privalikhin and Berzin 1978; Leatherwood and Reeves 1983). By measuring the genetic differentiation among species, Wada and Numachi (1991) identified two broadly divergent forms; a standard form and a smaller or pygmy form. They estimated that the two forms diverged about 4.1 million years ago and are so dissimilar that they should be regarded as distinct and separate species. Based on the phylogeny of mitochondrial DNA, Dizon *et al.* (1996) also concluded that the pygmy Bryde's Whale may be a separate species, more distinct from the standard form of the Bryde's Whale than is the Sei Whale *Balaenoptera borealis*.

A sample of the whale's skin and epidermal tissue was recovered from one of the nets penetrated by the whale during an unsuccessful attempt to capture it. Molecular genetic analysis of this material identified the animal as belonging to the pygmy form of Bryde's Whale (Priddel and Wheeler, in press). This form appears to have a restricted distribution and is known from only a handful of specimens (Dizon *et al.* 1996).

Sex

Molecular analysis of epidermal tissue also revealed that the entrapped whale was a male (Priddel and Wheeler, in press). The absence of testosterone in the blood indicated sexual immaturity *(ibid)*.

Size

Measurements of the whale entrapped in the Manning River were taken while it was grounded on 24 November 1994 (Table 1). Total body length, tip of upper jaw to centre of eye, and tip of upper jaw to tip of dorsal fin were measured in a straight line parallel to the longitudinal axis of the whale. Height of dorsal fin and the distance from notch to tip of fluke were also recorded.

Table 1. Morphometric measurements of the entrapped Bryde's Whale. % BL, measurement as a percentage of body length.

Measurement	Length (m)	%BL
Body length	10.30	
Tip of upper jaw to centre of eye	1.98	19.2
Tip of upper jaw to tip of dorsal fin	7.58	73.6
Height of dorsal fin	0.38	3.7
Notch of fluke to tip of fluke	1.32	12.8

The length of the entrapped whale was 10.3 m. The weight of a healthy Bryde's whale can be estimated from the following equation: $W = 0.50 \times 10^{-3} \times L^{2.74}$; where W = weight in tonnes, and L = body length in feet (Fujino 1955, amended by Gambell 1977). With this formula, the weight of the whale was estimated to be approximately 7.7 tonnes.

Male Bryde's Whales of the coastal race of the standard form attain sexual maturity at 9–10 years of age when they reach the length of 11.8–12.2 m (Best 1977); offshore races are approximately 10% larger. The numerical relationship between size and age has not been determined for the pygmy form of the Bryde's Whale.

Movements

Within hours of entering the river, the whale confined itself to the western end of the South Passage alongside Dumaresq Island approximately 23 km upstream from the river mouth (Fig. 2). As far as could be ascertained, the whale remained in this vicinity for several weeks. Although the whale disappeared for significant periods of time each day, it was rarely seen upstream of the island or downstream of Blackfords Bay. Noise emanating from pile

driving at a bridge construction site approximately 1 km downstream from Blackfords Bay may have deterred the whale from moving downstream through the South Passage.

Throughout its period of entrapment, the whale's movements were regular and methodical, generally following a predictable circuit that was often confined to a small stretch of the river. The whale repetitively swam the same circuit, seldom venturing beyond discernible boundaries. The predictability of its movements was the essential element of the whale's behaviour that made it vulnerable to capture.

Unsuccessful attempts to rescue the whale had a marked effect on its movements. After each rescue attempt the whale deserted its previous locale and swam to another section of the river. Prior to intervention, the whale spent most of its time in the South Passage near Dumaresq Island. After the drive, the whale adopted a new haunt downstream of Cattai Creek (Fig. 2). It was occasionally observed downstream as far as Manning Point. After an attempt to capture the whale at Chinamans Beach, the whale moved upstream to the area between Cattai Creek and Lansdowne River. After a second attempt to capture the whale in this area it initially moved into the South Passage, and shortly after it again relocated, this time farther downstream to within a few kilometres of the river mouth.

The most spectacular response of the whale to any intervention occurred immediately after the first attempt to net it. After eluding the nets, the whale swam rapidly upstream approximately 2 km then breached out of the water on six occasions in rapid succession. During the first two breaches, the whale reared entirely out of the water, arching its back in mid-air and twisting before crashing back into the river. The remaining breaches were successively less spectacular, and in the last, only half of the whale left the water, the animal lunging onto its back and side. On its first breach, the whale left the water almost vertically despite a water depth of only 6.8 m. Breaching is common in Bryde's Whale in some areas, and often follows periods of strenuous activity such as high-speed swimming (Carwardine 1995).

Diving Behaviour

While undisturbed in the river, the whale exhibited a quiet temperament. Exhalation and inhalation at the surface were unhurried and the subsequent submergence was slow and methodical. The only few instances of vivacious behaviour witnessed were what appeared to be attempts to feed (see below).

The whale spent only a few seconds at the surface to exchange air, and dived for periods generally lasting 4–7 min., with infrequent extremes of around 1 min. and 20 min. Similar extremes have been observed by Cummings (1985). Two types of swimming behaviour were distinguishable. The first involved movements which generally followed a predictable circuit over an area of relatively deep water. Such behaviour was accompanied by respiratory rates that were reasonably constant. The second behaviour involved more extensive and less predictable movements, the whale often traversing broad expanses of shallow water. This behaviour was characterized by comparatively longer dives and erratic respiratory rates.

Feeding Behaviour

Several attempts at feeding were observed. Feeding began with the whale swimming slowly in progressively decreasing circles, apparently to herd small shoaling fish. The whale then lunged several times (with sudden accelerations and changes in direction) and rolled to one side, on occasion exposing the baleen. The quantity of food ingested, if any, is unknown.

Vocalizations

While submerged, Bryde's Whales can produce simple but powerful vocalizations often referred to as moans (Thompson *et al.* 1979; Clark 1990). Underwater sounds in the vicinity of the entrapped whale were investigated. Ambient sounds and boats were heard but no distinguishable whale vocalizations were detected. The lack of vocalizations may have been due to the absence of other members of its kind.

Body Condition

Throughout the period of the whale's entrapment uncertainty existed as to the whale's general condition and state of health. Although every opportunity was taken to observe the whale as it swam at the surface or rose to breathe, assessments of the whale's well-being varied. Several veterinarians and marine mammal biologists thought the whale was losing condition. Apparent hollowing of the flanks and back was interpreted as a sign of weight loss and deterioration of body condition. However, over the period of the whale's entrapment, there was no discernible lateral body instability, no discernible change in the whale's behaviour or speed of travel, nor in the height and strength of the blow. Both nares seemed to be operating efficiently and equally.

Pathological analysis of the epidermal tissue recovered from the net holed by the whale found no physiological abnormalities or any evidence of active inflammation. Close examination of the animal was possible only when the whale eventually grounded. The whale was

clearly emaciated. Rather than being smooth and rotund, the back and flanks dipped away markedly either side of the vertebrae. The dorsal fin was not erect throughout its height, the apex being flaccid and leaning to one side. The emaciated state of the whale supported predictions that it would be unable to obtain sufficient food in the river to maintain body condition.

Several patches of skin were discoloured but there was no evidence of any skin loss or sloughing. Comparison with previous observations indicated that these dermal blemishes had become more intense during the period of entrapment. Approximately 15 longitudinal scratches (200–1 200 mm) were evident along the dorsal surface and flanks; one was up to 6 mm deep, the others were largely superficial. These wounds were almost certainly incurred when the whale broke through the nets. The leading edge of both caudal flukes was severely abraded. These wounds, probably caused by ongoing abrasion against the sandy bottom as the whale turned or attempted to manoeuvre in shallow water, were raw and bleeding. Best (1977) found long thin scratches on the undersurface of the caudal flukes and along the ventral keel of the peduncle in several whales of the coastal form and attributed these injuries to contact with the sea floor.

Pathological analysis of blood samples taken during the final rescue operation provided the only objective assessment of body condition (Priddel and Wheeler, in press). Despite the visible indications of emaciation and clinical evidence of malnutrition, there was no discernible physiological damage due to the protracted period of entrapment in the river. Cetaceans maintain salt and water balance through the ingestion of food, which provides both the free-formed water and additional water derived from the oxidation of fats (Geraci 1978). When food intake falls below subsistence levels, water balance ultimately can be compromised leading to the onset of dehydration and electrolyte disorder *(ibid).* The contrast between the whale's poor body condition and its relatively healthy blood chemistry suggests a state of metabolically compensated starvation. Although the whale had greatly depleted its energy reserves, it was rescued from the river before the onset of ill health or irreparable physiological damage.

Some kidney insufficiency was apparent but organ damage was more likely to have been caused by parasitism rather than entrapment. The whale showed clear biochemical signs of stress during the final rescue attempt but this stress was not considered severe.

DISCUSSION

As stated, debate has occurred since the rescue regarding the need for such intervention. A fundamental issue was the question of whether the whale was effectively trapped and unable to return to the ocean unaided. Repeated groundings near the river mouth suggested that the whale had difficulty entering the shallow channel running between the training wall and the network of sand shoals (Fig. 3). Increased river flows following heavy rain would normally enlarge the channel through the river mouth, perhaps sufficient for the whale to return to the ocean of its own accord. One option, therefore, was simply to wait and let nature solve the problem. With the benefit of hindsight, this approach would have failed. Although river flow has increased in the year since the rescue was completed, the volume of water has been insufficient to scour a deeper channel through the river mouth.

The occurrence of a large whale in the Manning River is a rare but not unprecedented event. Most whales that have entered the river, however, have stranded and died. On the several occasions that the present whale became grounded on sand shoals it managed to refloat itself on the rising tide. Nonetheless, each of these groundings was potentially life-threatening. Thus, judging from previous incidents, and from the apparent inability of the whale to find its own way out to sea, it was reasonable to conclude that the entrapped whale would probably die if not rescued by human intervention.

Under the *National Parks and Wildlife Act (1974)* the NSW National Parks and Wildlife Service is charged with a legal responsibility for the care and protection of all marine mammals. The Service also has a responsibility to prevent or alleviate circumstances likely to cause distress to any protected animal. There was clearly a legal obligation to ensure the humane transfer of the whale from the unsafe situation it was in to its more familiar oceanic environment.

At issue was the time, and the extent, of intervention by the Service, particularly when such intervention could itself be life-threatening. The initial response of the Service had been to close the stretch of river where the whale first took up residence. As the whale became more wide-ranging it was clear that such action was no longer appropriate. The restrictions on entering the South Passage were revoked in favour of establishing an exclusion zone around the whale. Despite this action the whale remained vulnerable to accidental collision with river traffic, as well as to the potential threats of stranding, starvation, and exposure to low salinity and high acidity.

About 50 days after the whale entered the river, the decision was taken to embark on a rescue bid to remove the animal from the river and return it to the ocean. The overriding consideration underpinning this course of action was that the whale was thought to be unable to return to its normal oceanic environment on its own, and that it was exposed to several threats to its well-being. Of major concern was the uncertainty about whether the whale was able to obtain sufficient food in the river to sustain itself. Cetaceans have a great capacity to live off body reserves but once these have been metabolized an individual's health could be expected to deteriorate rapidly. Body organs may be irreparably damaged by the time blood chemistry reflects malnutrition (Sweeney 1990). Considering the emaciated condition of the whale and the clinical signs of catabolism at the time of its rescue, it was unlikely to have survived much longer had it remained in the river. Any rescue attempt initiated after definitive signs of deterioration became evident may have been to late to save the animal.

Very little information was available from similar incidents to assist in the formulation of a rescue plan. Biological and behavioural information for the Bryde's Whale was also scant. Despite these constraints, the rescue operation eventually culminated in the safe return of the whale to the ocean. The whale swam away strongly on release and its chances of survival appeared to be good.

It may be argued that the rehabilitation of a single individual contributed little to the conservation of the species. Bryde's Whales are probably more secure than any other species of Baleen Whale, mainly because they inhabit tropical and low latitude waters most of which have been closed to pelagic whaling since the 1930s by measures intended to protect the breeding grounds of other, less secure species (Klinowska 1991). This particular individual, however, was of the rare pygmy form of the Bryde's Whale which has a restricted distribution and is known from only a few specimens; its conservation status in the wild is unknown. Moreover, public interest in the plight of the entrapped whale was enormous. The attempts to rescue the whale received national and international media interest and undoubtedly heightened public awareness of the occurrence of whales in Australian inshore waters. The benefit of such increased awareness is that it engenders a greater concern for whales, which in turn provides a greater impetus for governments to act to conserve marine mammals and their marine habitats.

Although the safe and humane return of the whale to the ocean was the primary goal of the rescue operation, other benefits were apparent. The experience gained in this incident will prove invaluable when the need arises to rescue other large whales that may become entangled, stranded or entrapped in New South Wales waters. The incident validated the usefulness of several techniques untried previously in this part of the world, techniques that can now be used with confidence to rescue individuals of more endangered species or, in circumstances such as entanglement, where the need for intervention is urgent.

It would be of advantage if satellite radio-transmitters were routinely attached to rescued or rehabilitated whales in order to monitor their survival after release. The data obtained will not only serve to assess the merit of the rescue operation, but will add to our knowledge of whale behaviour, movements and migratory patterns, thereby enhancing our ability to conserve these majestic creatures.

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